Future scenarios for climate change and coasts.

- Inland Climate (Nick Reynard)
  - Precipitation
  - Temperature
- Coasts (Robert Nicholls)
  - Net sea-level rise
  - Storm surge
  - Waves
  - Morphology

Climate Drivers

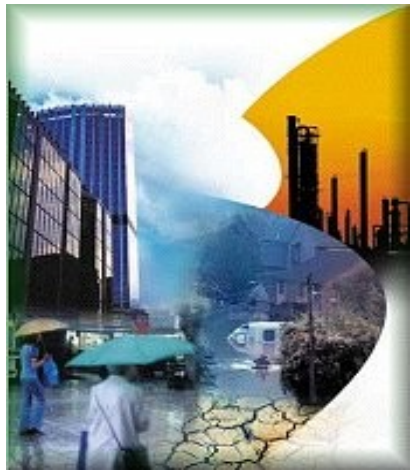
- Precipitation
  - Rainfall
    - Annual / seasonal change
    - Long / short duration
    - Variability
  - Snow
  - Estimating impacts of changes on flood risk
- Temperature
  - Precipitation
  - Evaporation

The UK Climate Impacts Programme

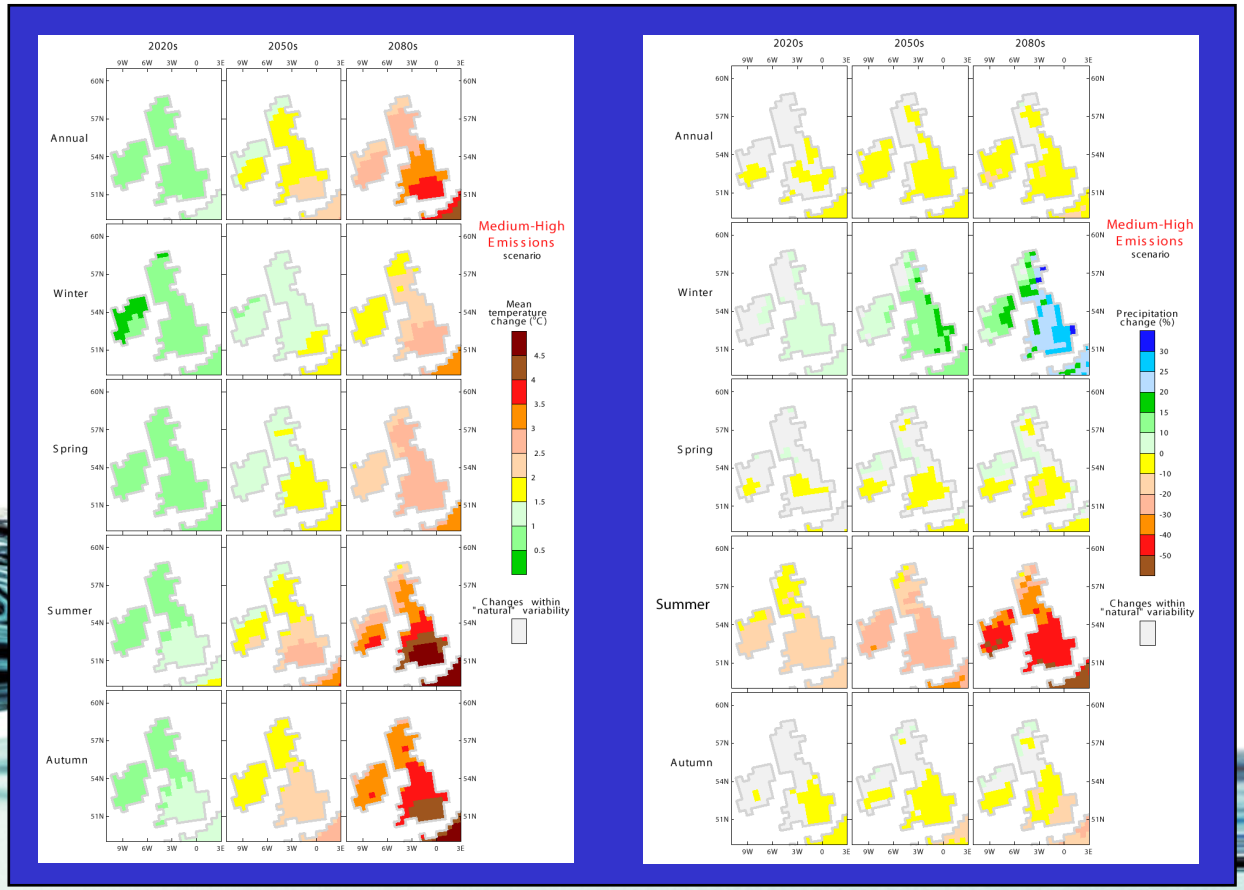
- Funded by the Department of the Environment, Food and Rural Affairs (Defra)
- Established in 2000
- Based at the University of Oxford
- Objectives:
  - Understanding the impacts of climate change (scenarios)
  - Equipping for adaptation (decision-making tools)
  - Working in partnership
  - Providing information on impacts and adaptation
  - Learning from the international scene

Climate Change in the UK

Future Flooding



UKCIP02 Technical report

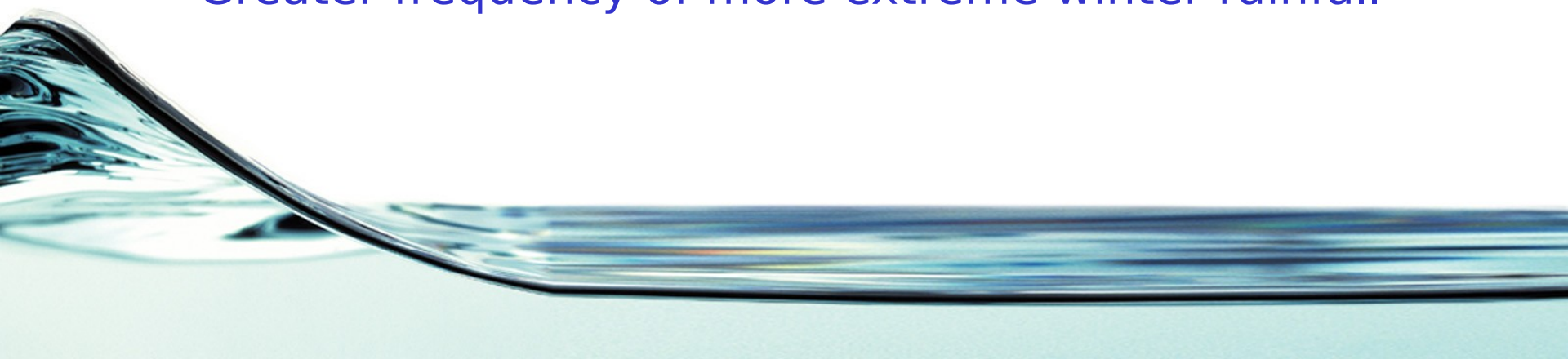


Summers will be hotter (1℃ to 5℃) and drier (10 to 50%)

Winters will be milder (1℃ to 3.5℃) and wetter (5 to 40%)

UKCIP02 – How will UK climate change?

- Average annual temperatures may rise by 2-3.5° C
- Annual average precipitation across the UK may decrease slightly (but may be large regional differences)
- Winters likely to become wetter and summers drier – with biggest changes in the South and East
- Summer soils likely to become drier
- Greater frequency of more extreme winter rainfall



UKCIP02 and Foresight 2004

High emissions	→	World markets
Medium-high emissions	→	National Enterprise
Medium-low emissions	→	Local Stewardship
Low emissions	→	Global Sustainability

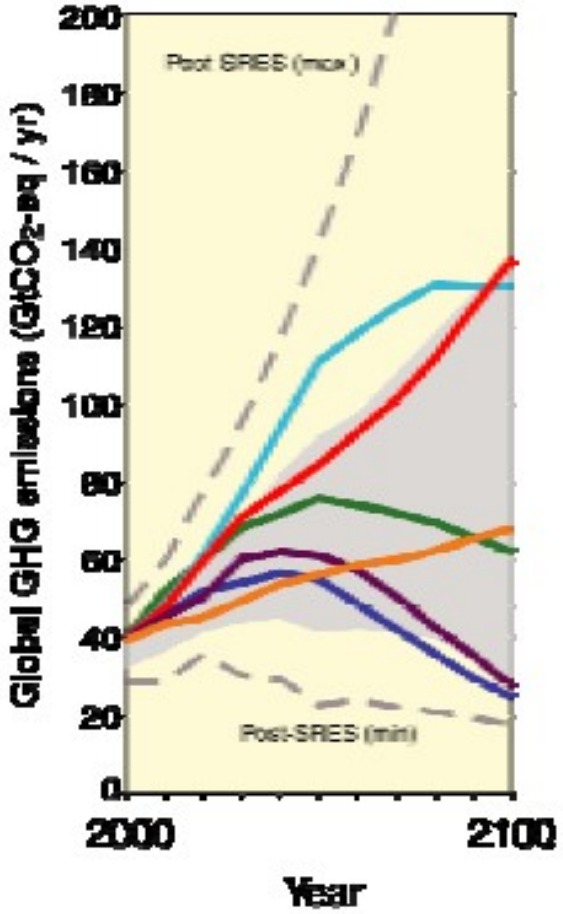
“Native parameters” - 2004

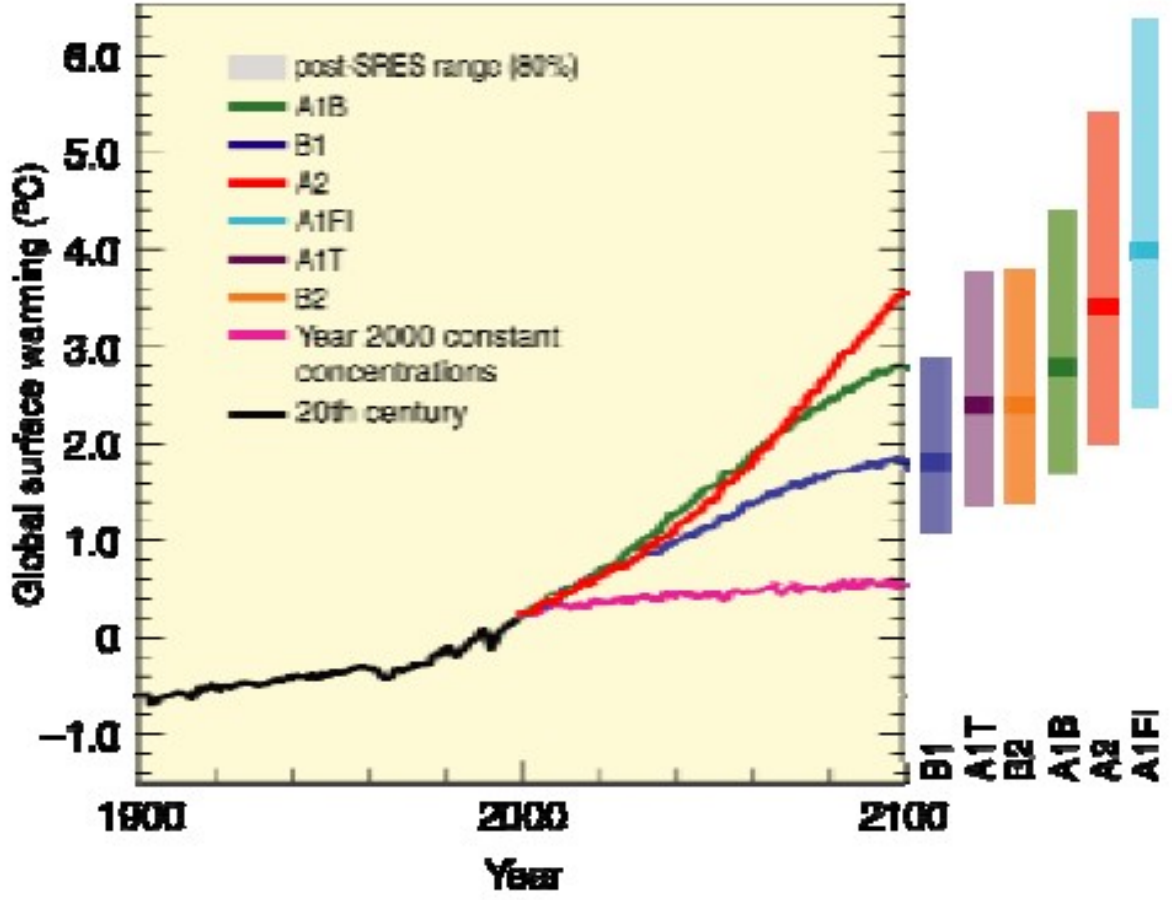
Future Flooding

Scenario 1: World Markets / UKCIP02 High Emissions

Driver	Driver Name	Change in Native Parameter	
		2050s	2080s
1-S	Annual precipitation	-5%	-8%
1-S	Winter precipitation	15%	25%
1-S	Summer precipitation	-30%	-50%
1-S	Rainfall intensity – winter	12%	20%
1-S	Rainfall intensity – summer	-18%	-26%
1-S	Temporal sequencing	6%	12%
1-S	Snow	-40%	-80%
1-S	Soil moisture – summer	-20%	-40%
1-S	Spatial extent	Increase	Increase
4-S	Average winter temperature	1.5ºC	2.5ºC
4-S	Average summer temperature	2.5ºC	4ºC

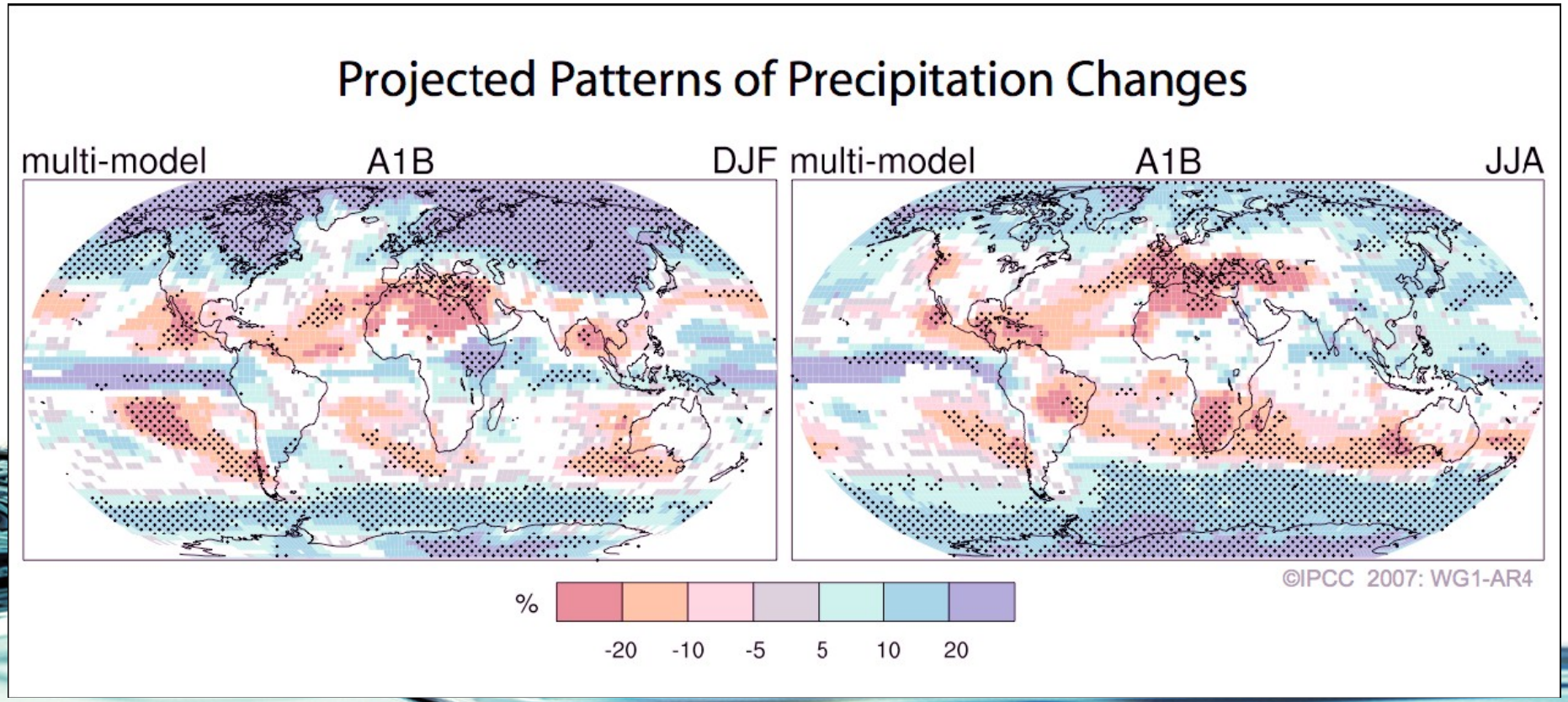
IPCC AR4 scenarios



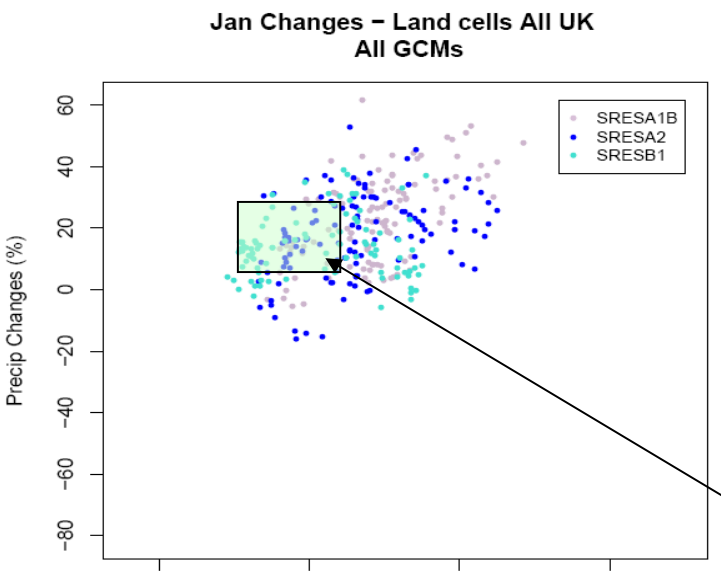


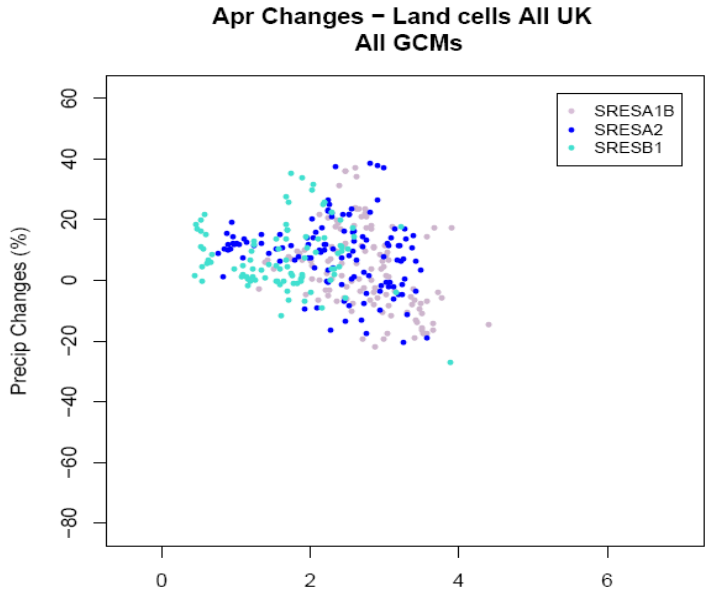
Relative changes in precipitation (in percent) for the period 2090–2099, relative to1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change.

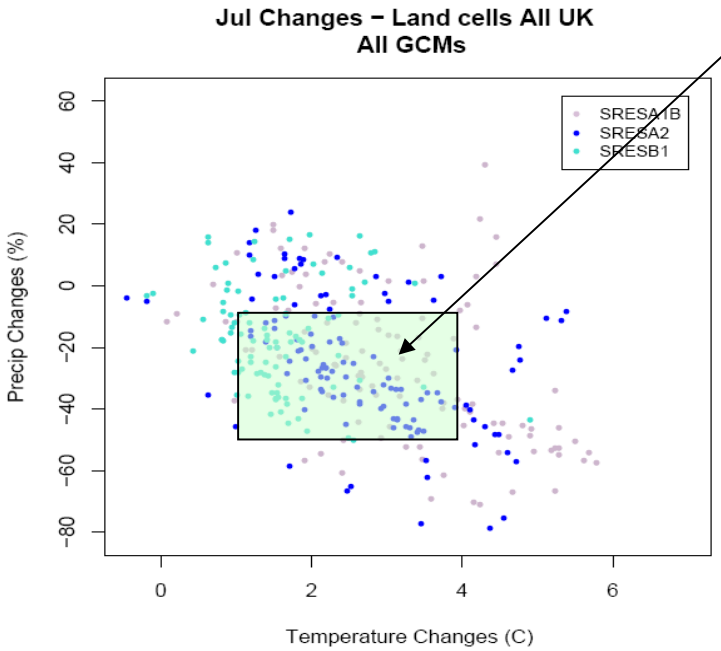
IPCC 2007



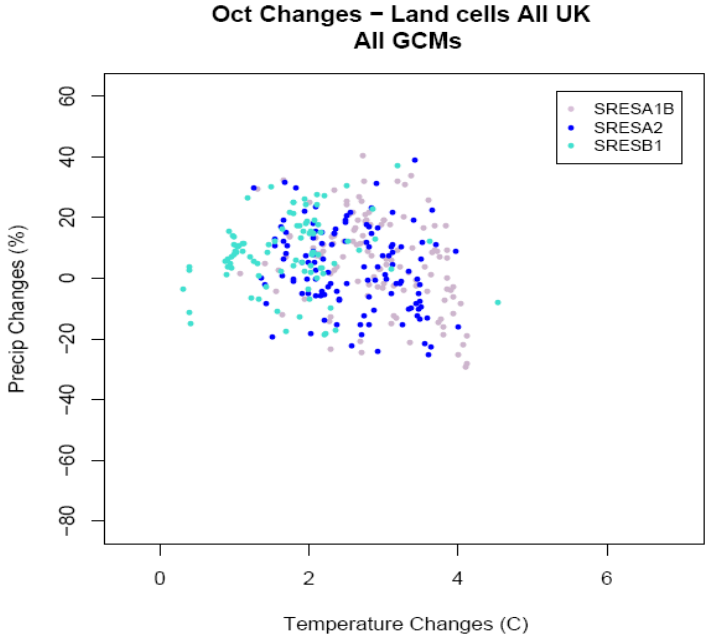
GCM uncertainty – 2080s



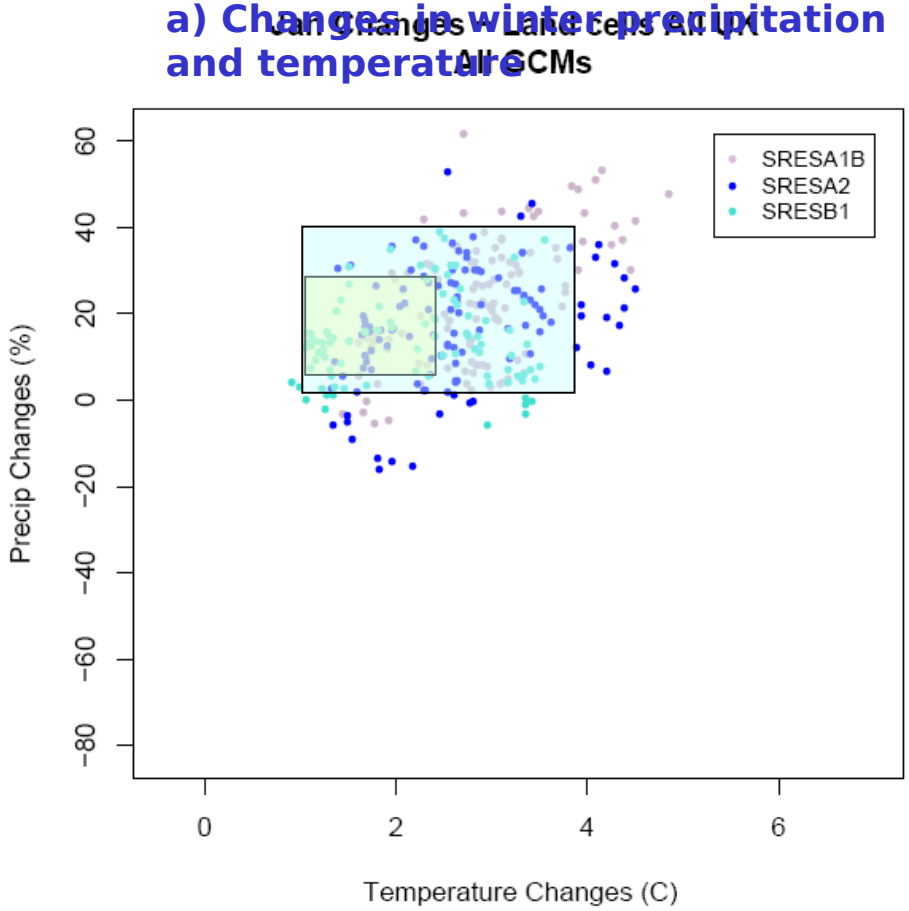




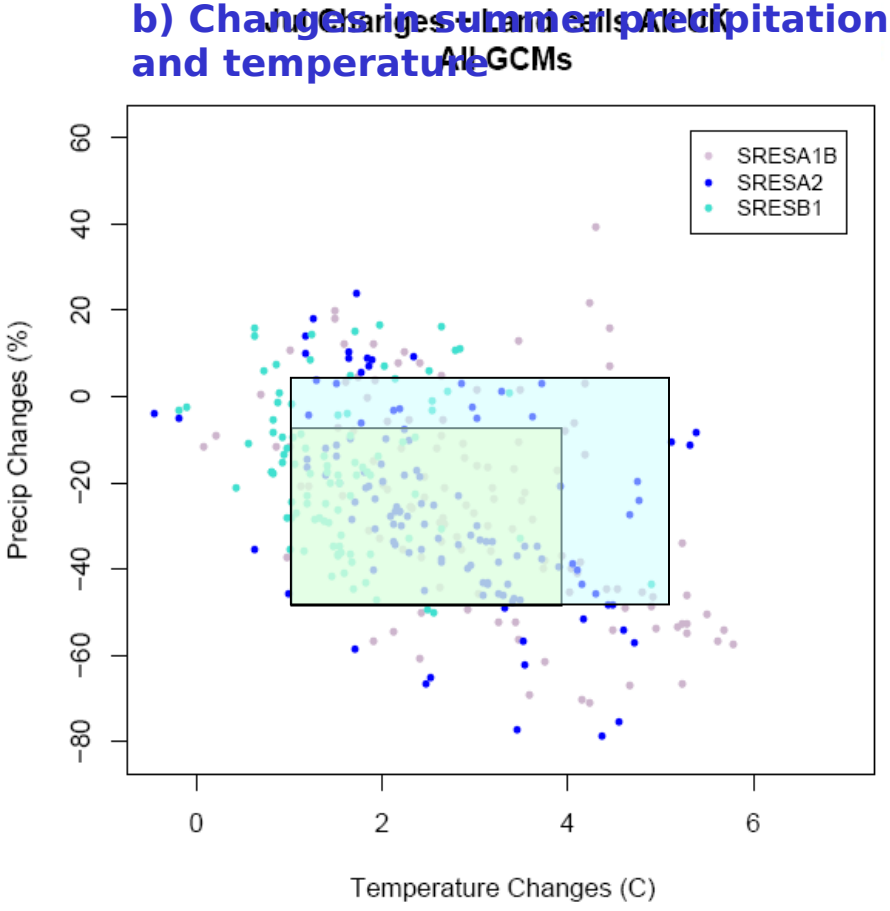
Original (UKCIP02) Foresight space



a) Changes in winter precipitation and temperature



b) Changes in summer precipitation and temperature



“Native parameters” – 2008

Future Flooding

Scenario 1: World Markets / UKCIP02 High Emissions

Driver	Driver Name	Change in Parameter	
		Original	New ???
1-S	Annual precipitation	+5% to -8%	+10 to -20%
1-S	Winter precipitation	+5 to +25%	0 to 35%
1-S	Summer precipitation	-10 to -50%	0 to -50%
4-S	Average winter temperature	1 to 2.5ºC	1 to 4ºC
4-S	Average summer temperature	1 to 4ºC	1 to 5ºC

Change in annual, summer and winter temperature for the UK by the 2050s and 2080s.

Scenario	2050s			2080s		
	Annual	Summer	Winter	Annual	Summer	Winter
World Markets	2.5	3	2	4.5	5	4
National Enterprise	2	2.2	1.5	3	3.5	3
Local Stewardship	1.3	1.5	1	2	2.5	2
Global Sustainability	0.7	0.7	0.5	1	1	1

Percentage change in annual, summer and winter precipitation for the UK by the 2080s.

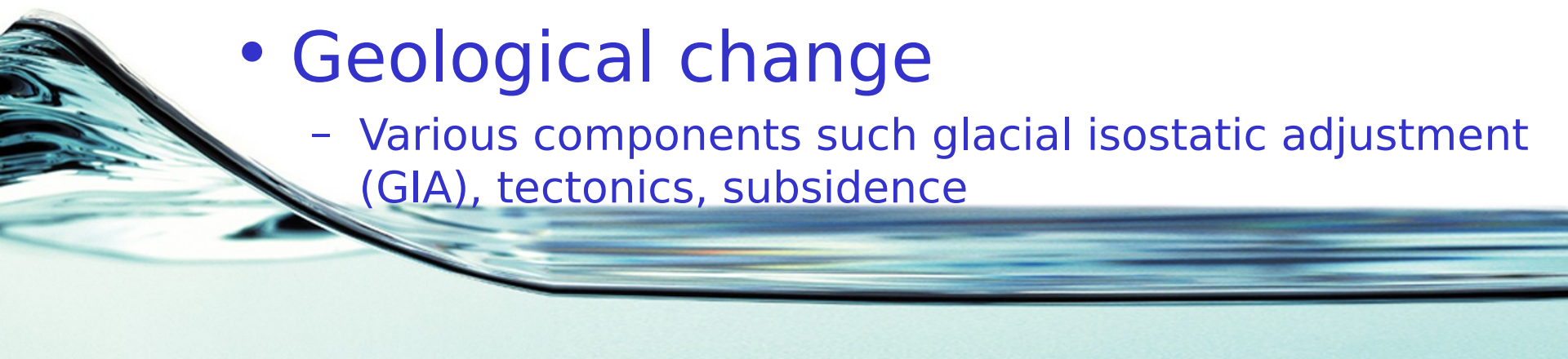
Scenario	Annual total	Summer			Winter		
		Total	Interannual variability	Intensity	Total	Interannual variability	Intensity
WM	10	0	50	60	40	10	35
NE	0	-20	35	40	30	0	20
LS	-10	-40	20	25	20	-10	5
GS	-20	-60	5	10	10	-20	-10

Coastal Drivers

- Relative sea-level rise (source). Local change of sea-level relative to the land;
- Surges (source). Temporary change (rise) in sea-level resulting from meteorological forcing of the ocean surface;
- Waves (source). Wind-induced disturbance of the sea surface that propagates across the surface;
- Coastal morphology and sediment supply (pathway). Changes in the form of the seabed, shoreline and adjacent coastal land, coastal inlets and estuaries.

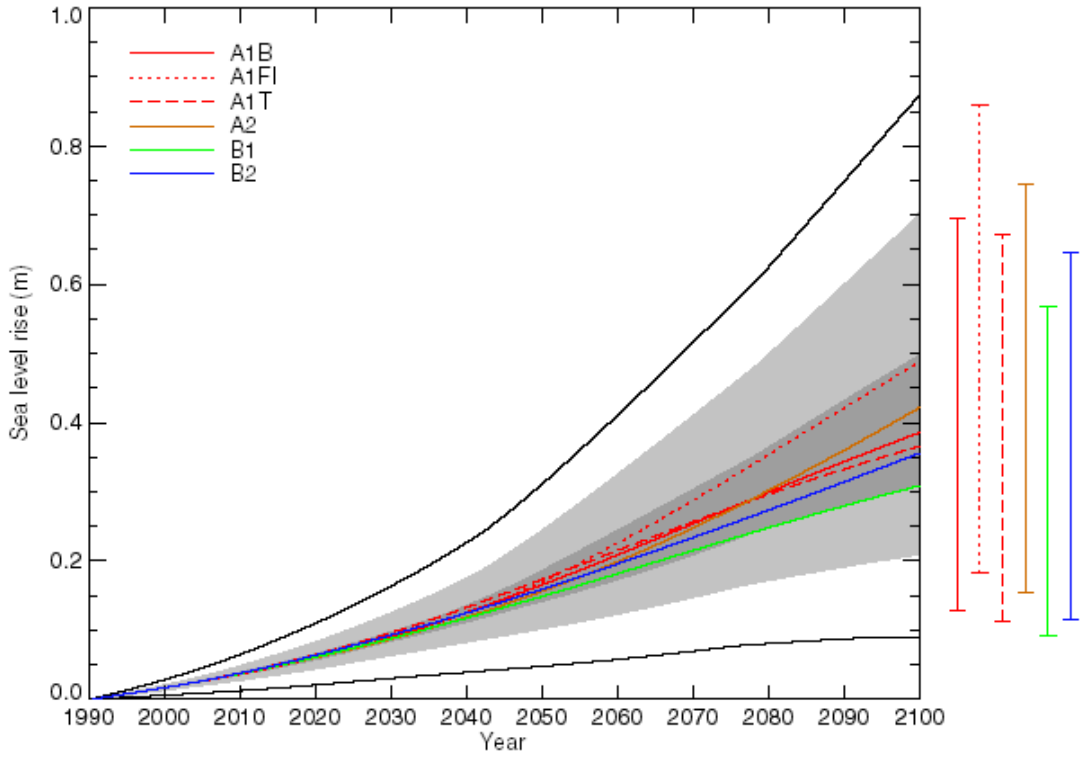
Components of Sea-Level Change

- Global-mean change
  - Ice balance/average thermal expansion,
- Ocean basin (i.e. North Atlantic) change
  - Pattern of sea-level change due to thermal expansion, changing ocean circulation, mean wind fields, etc.
- Geological change
  - Various components such glacial isostatic adjustment (GIA), tectonics, subsidence



Global-mean sea-level rise

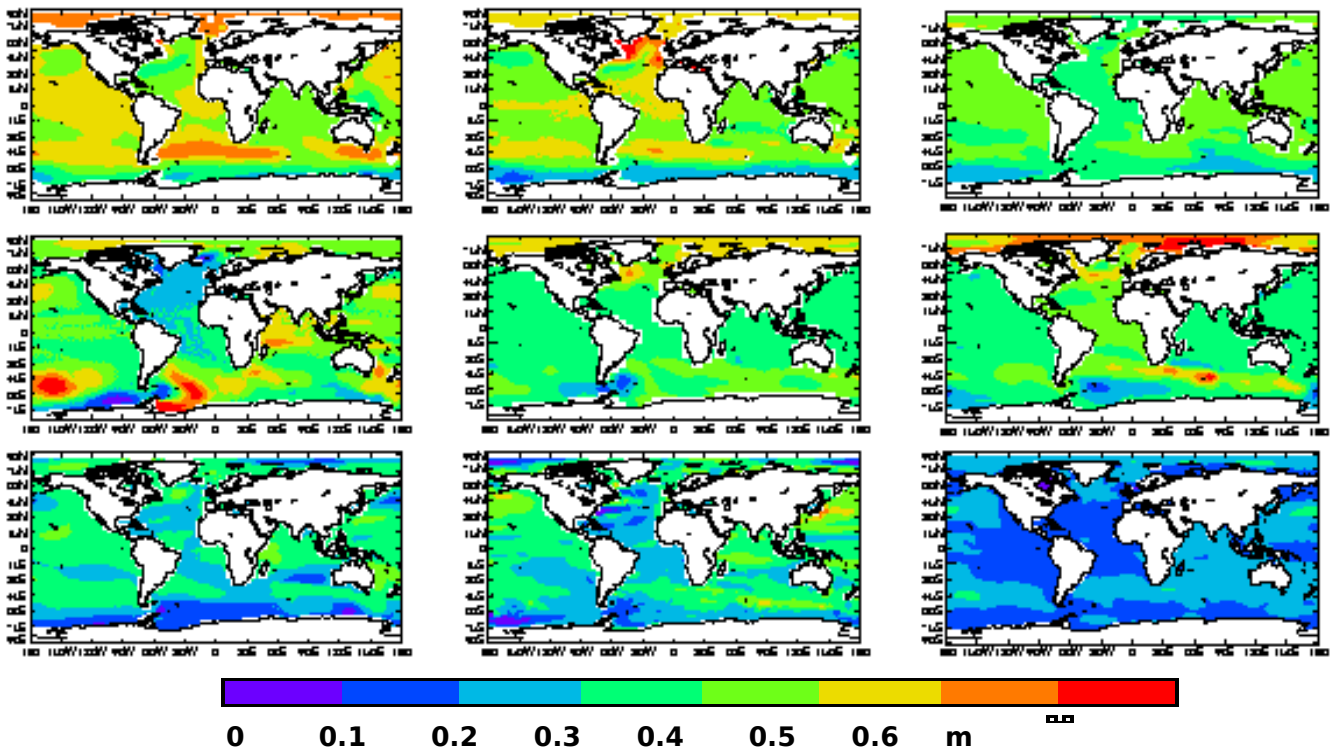
IPCC Third Assessment Report



Regional Sea-Level Change

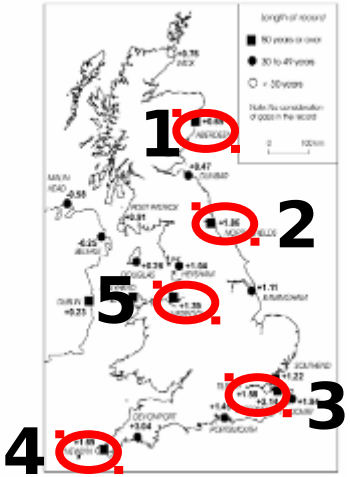
± 50% uncertainty in global-mean component

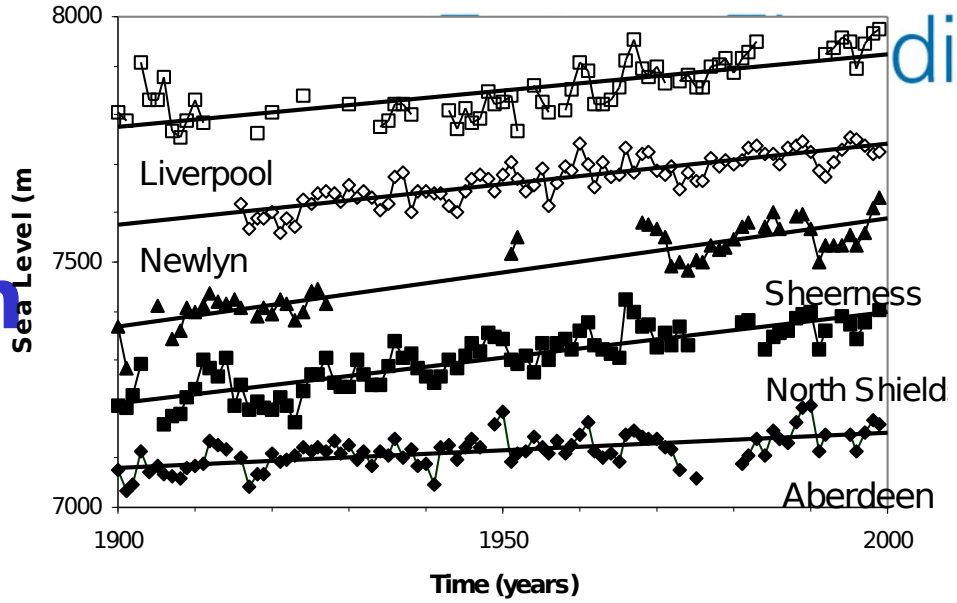
IPCC Third Assessment Report



Sea-level trends around Britain

(de la Vega-Leinert and Nicholls)

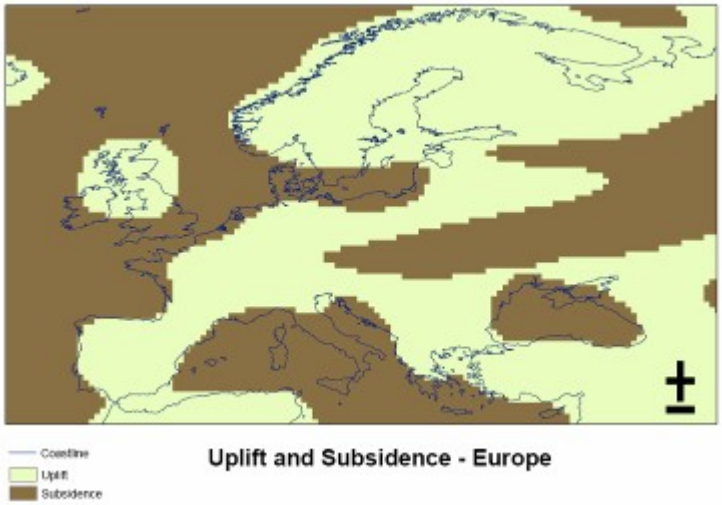




Station	*MSL trend (mm/yr)*	*Length of record*	*Complete years*
1. Aberdeen	+0.69	1901-96	86
2. North Shields	+1.86	1901-96	77
3. Sheerness	+2.14	1901-96	51
4. Newlyn	+1.69	1916-96	80
5. Liverpool	+1.39	1901-96	62

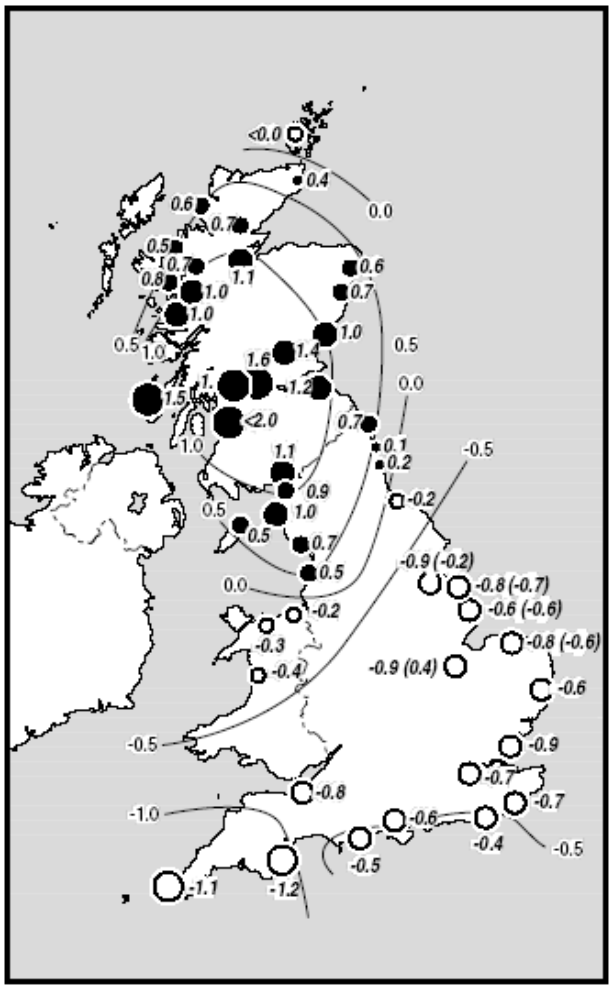
Geological Observations

(from Shennan and Horton, 2002)



Uplift and Subsidence - Europe

Relative sea-level rise model due to Glacial Isostatic Adjustment (from Glenn Milne, Durham)



Subsidence

Uplift

Regional Application:

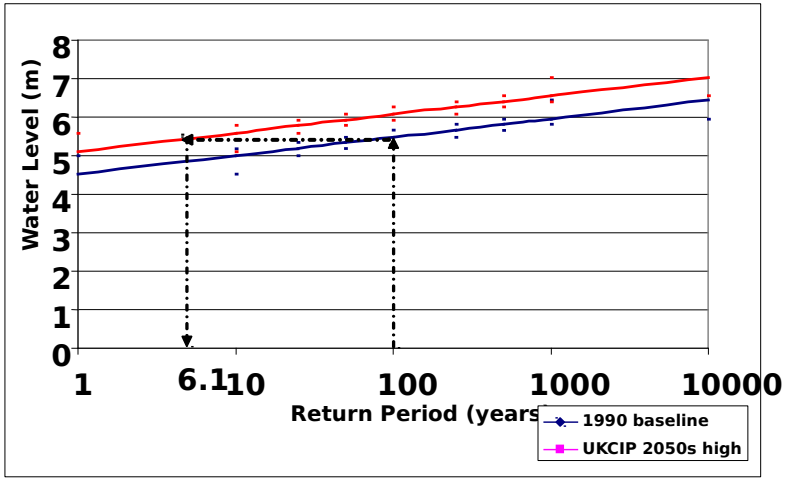
Relative Sea Level 1990 to 2080s

Note: Subsidence is negative.

REGION	Mean uplift/ subsidence (mm/yr)	RSL Scenario (cm) Low Emissions	High Emissions
East Scotland	1.0	34	55
North East England	0.2	41	62
Yorkshire	-0.5	48	69
East Midlands	-0.6	49	70
East England	-0.7	50	71
London	-0.7	50	71
South East England	-0.5	48	69
South West England	-1.0	53	74
Wales	-0.4	47	68
North West England	0.7	36	57
South West Scotland	1.3	31	52
North West Scotland	0.7	36	57

Sea-Level Rise and Extreme Sea Levels

(from Nicholls and Wilson, 2001)

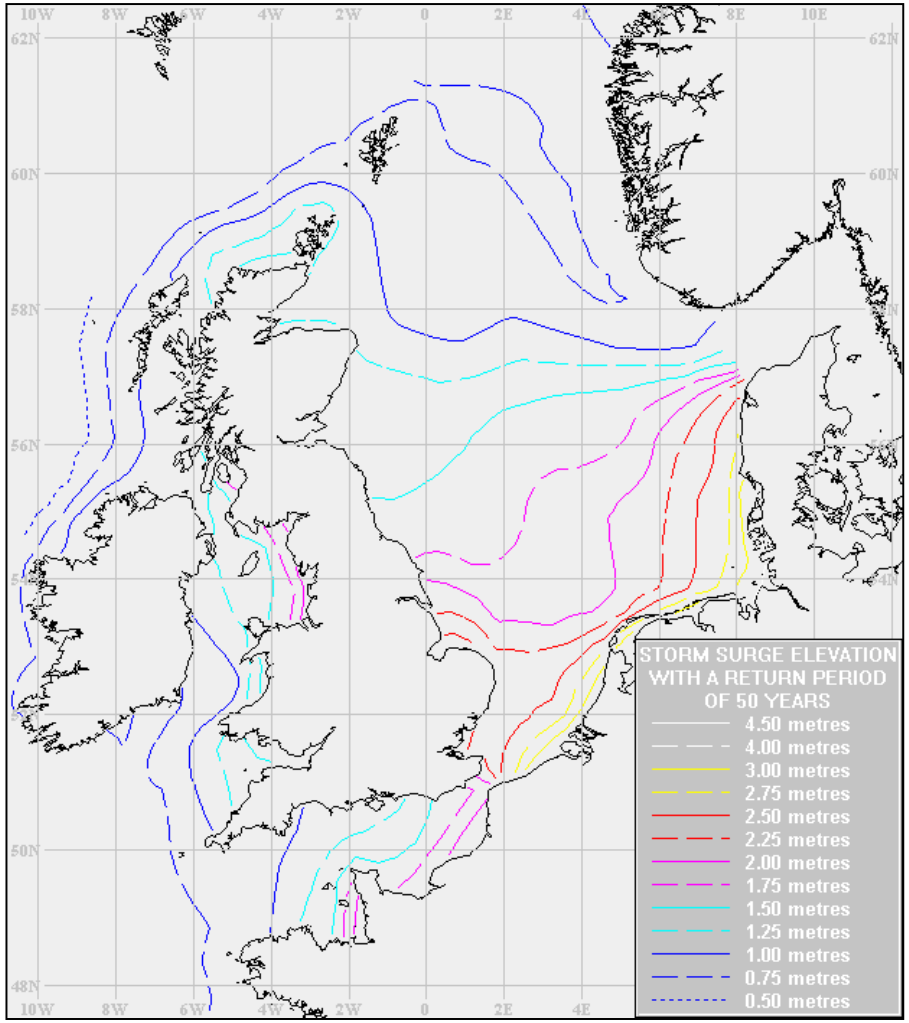


Global sea-level rise (cm)	*Future return period (years) for the present 100 year event* *East Anglia* *North West*			
	Average	Range	Average	Range
09	72	64 - 78	68	63 - 71
35	21	13 - 26	21	15 - 25
50	10	5 - 14	11	6 - 13
64	5	2 - 8	6	3 - 8
96	1	<1 - 2	1	<1 – 2

Storm surge

50-year event

(from UKDMAP, 1998)



Changes to surges

1:50 storm surge level

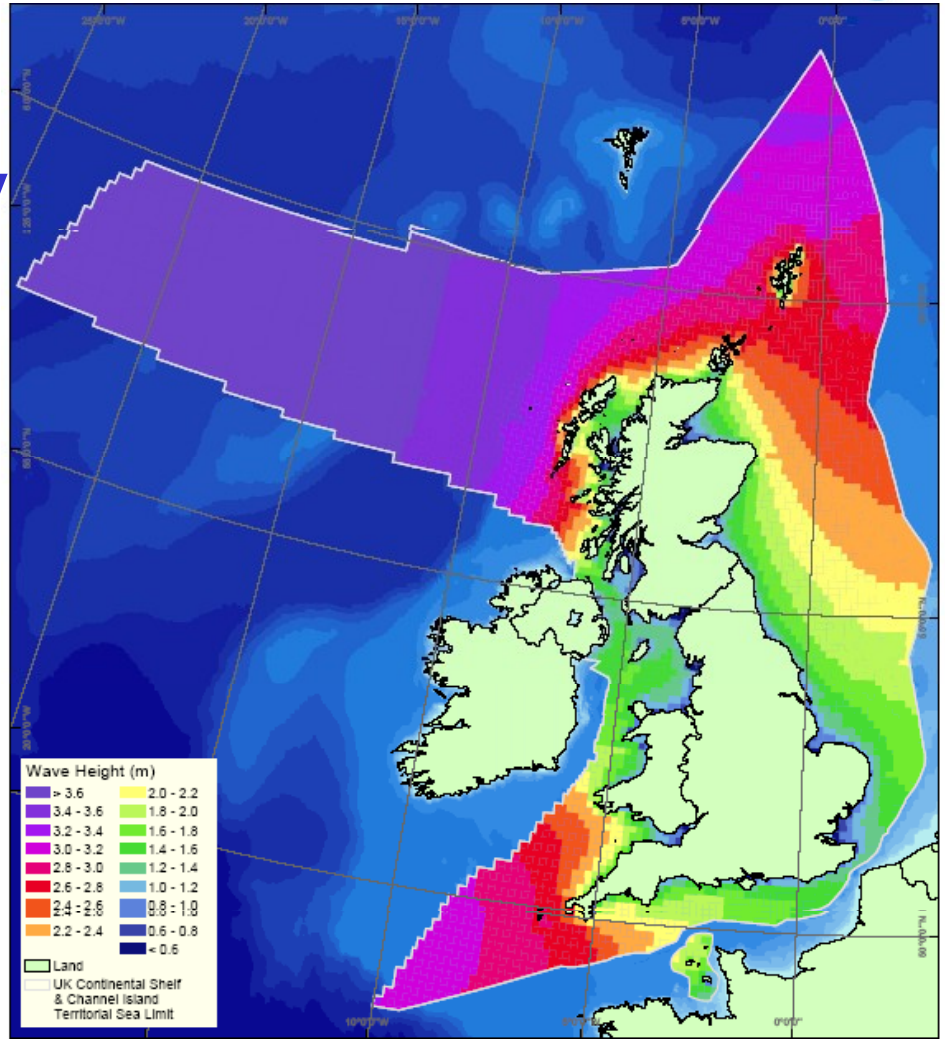
Future Flooding

LOCATION	*CURRENT SURGE (m)*[1]	*GLOBAL SUSTAINABILITY (m)*[2]	*NATIONAL ENTERPRISE (m)*[2]	*WORLD MARKETS (m)*[2]
Sunderland	1.5	1.6	1.9	2.3
Flamborough Hd	1.75	1.95	2.15	2.55
Sheringham	2.25	2.75	2.95	3.35
Canvey Island	2.5	3.4	3.9	4.0
Dover	2.5	3.2	3.7	3.8
Isle of Wight	1.0	1.2	1.5	1.8
Lands End	0.75	0.95	1.15	1.55
Blackpool	1.75	1.85	2.05	2.45

Significant wave height

exceeded 10% annually UK Continental Shelf

(ABPmer, 2004).

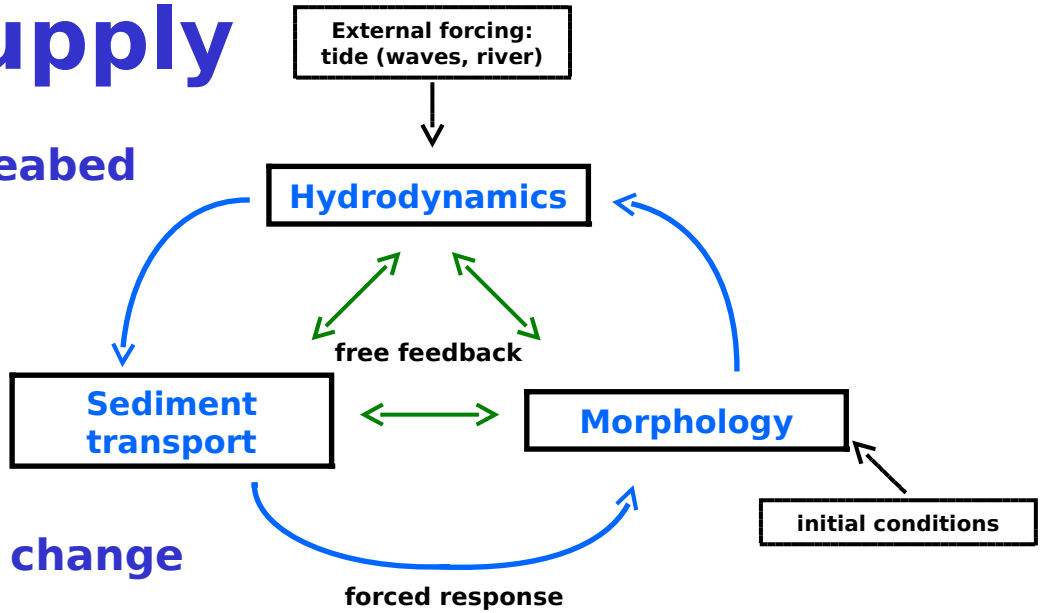


Coastal morphology and sediment supply

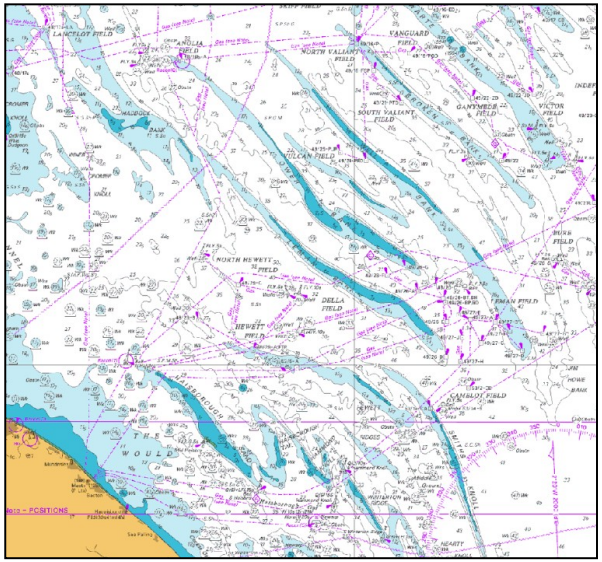
- Offshore changes to shallow seabed
- Open coast changes
- Estuarine changes

Controlled by

- Sediment availability
  - Sea-level rise and climate change
  - Coastal management



Coastal morphology and sediment supply -- examples



Seabed changes
-- wave climate

Cliff changes
-- sediment supply

Dune changes
-- flood pathways

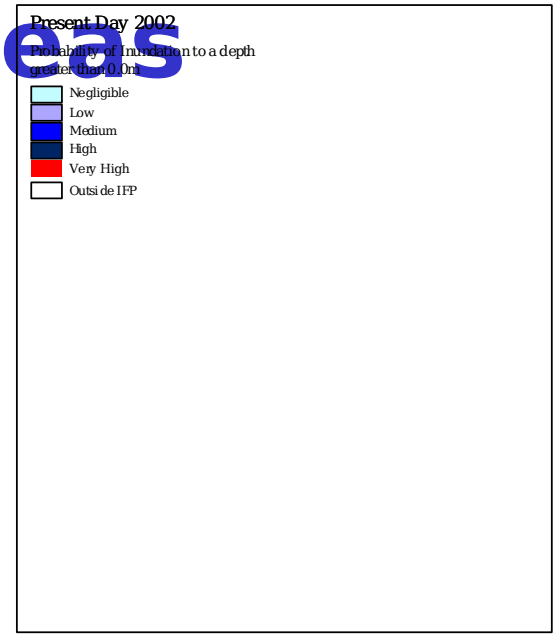
Flood risk rankings

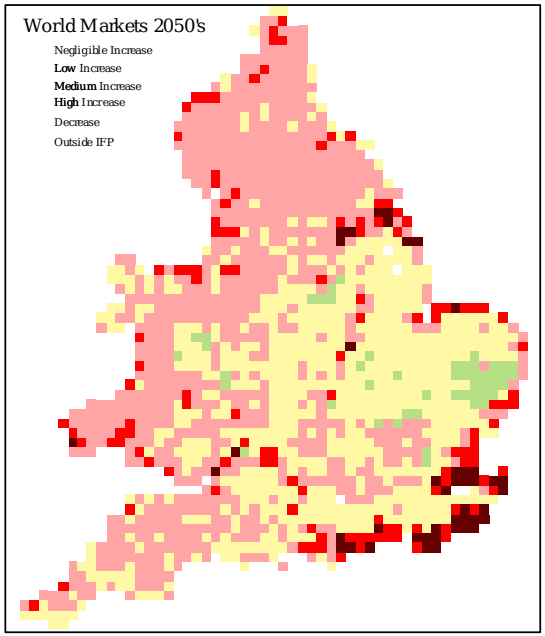
Coastal process drivers -- 2080's.

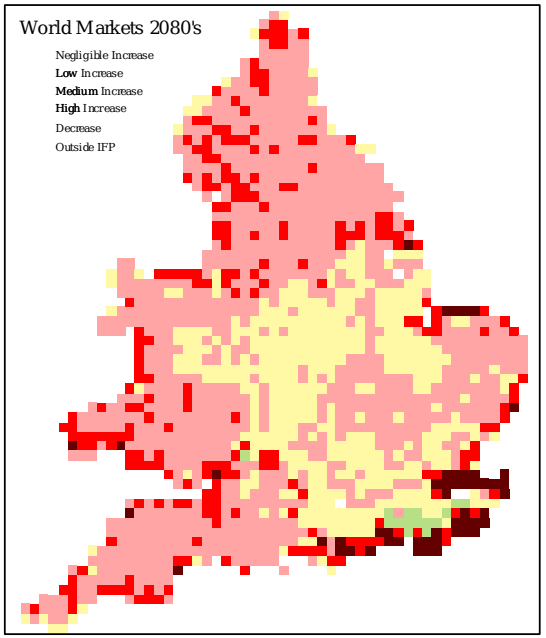
Future Flooding

COASTAL PROCESS DRIVER		WORLD MARKETS	NATIONAL ENTER-PRISE	LOCAL STEWARD-SHIP	GLOBAL SUSTAIN-ABILITY
Waves	rank	7	9	8	12
	uncertainty	H	H	M	L
Surges	rank	3	3	4	10
	uncertainty	H	H	H	M
Relative Sea-Level Rise	rank	2	1	2	2
	uncertainty	H	H	H	H
Coastal Morphology	rank	6	5	7	9
	uncertainty	H	H	H	M

Flooding and coastal areas







Conclusion

A set of climate and coastal scenarios were developed which captured their uncertainties and allowed comparison with other drivers.